Field reactive system M-21

Classification:

Basing:	Car chassis
Purpose:	Multiple launch rocket systems
Warhead:	Smoky , Incendiary , Cassette , High-explosive fragmentation , Chemical
Control system:	Uncontrollable
The country:	Russia
Range:	20 km.
Year of development:	1963

The M-21 field rocket system is designed to destroy open and sheltered manpower, unarmored vehicles and armored personnel carriers in the concentration area, artillery and mortar batteries, command posts and other targets.

On May 30, 1960, the Resolution of the Council of Ministers of the USSR No. 578-236 on the beginning of development work on the new system was issued and the Main Artillery Directorate issued tactical and technical requirements No. 0010044 for development work: “Field rocket system“ Grad ”(approved on 26.05. 1960; out. From GAU a / 579686 dated 2.06.60).

The development of the combat vehicle was carried out by specialists from the State Design Bureau of Compressor Engineering, located in the city of Sverdlovsk (now Yekaterinburg). The chief designer was A.I. Yaskin. The development of the unguided rocket was carried out by the teams of the Research Institute-147 and related enterprises. NII-147 was headed by a talented designer Alexander Nikitovich Ganichev. In 1961, the factory testing of the Grad divisional field rocket system was completed, which consisted of a 122-mm 3OF10 unguided missile and a 2B-5 mobile launcher. From March 1 to May 1, 1962, in the Leningrad Military District, the State polygon-military tests of the complex took place. As a result of the work carried out, according to the decree of the Council of Ministers of the USSR No. 372-130from 28.03.1963 “On the adoption of the field reactive system“ Grad ”, the Council of Ministers of the USSR decided“ *to accept the proposal of the Ministry of Defense of the USSR on the adoption of the field reactive system “Grad” by the Soviet Army.* When the known indexes (BM-21, M-21-OF, etc.) were assigned to the elements of the new system is not documented. The M-21 system was a divisional link system, now it is better known as the 9K51 Grad multiple launch rocket system.

For the history of creation and testing of the future M-21 Field Reactive System - see the article by S.V. Gurov on our website.

MLRS 9K51 "Grad" for several decades in large quantities was produced by the defense industry of the USSR and is currently the most massive combat vehicle of this class. For example, only at the Motovilikha factories about 3 thousand BM-21s and more than 3 million shells for them were manufactured. The release of this system and its modifications was also established in China, Egypt, Iraq, Iran, Romania and South Africa. The system is currently in service with the armies of more than 30 countries around the world. At the beginning of 1994, the Armed Forces of the Russian Federation had 4,500 Grad MLRS and about 3,000 in the armies of other countries. Romania has delivered 53 Grad MLRS to the USA and 20 Grad MLRS to Cameroon.

Serial production of the 9M22 projectile for the Grad MLRS has been organized since 1964 at the Shtamp plant, mainly in the area of cartridge case production. Production of ammunition for MLRS "Grad" at this plant continued until the end of the 80s of the XX century. Mikhail Mikhailovich Tarabarchev was one of the managers who had the difficult task of mastering this production.

In 1963, the development of the technology for equipping the product 9M22U began at the enterprise p / box 8918 (now OJSC "Bryansk Chemical Plant named after the 50th anniversary of the USSR", Seltso, Bryansk region). Initially, the assembly was carried out on manual threads. In 1968, this enterprise carried out work on the introduction of an automated assembly line in building No. 1, and in 1968 it was put into operation. Later, on the basis of the Minister's order No. 262 dated 08/30/1968, construction work began on the creation of a complex for outfitting the warheads of 9M22U products (workshop No. 3) and serial production of 9M22U and 9M22M products was launched .

In 1972, building No. 4 of the branch office of PO Box 8918 was put into operation, in which an automated assembly line for the 9M22U product line was also mounted. This line was distinguished by higher productivity, manufacturability and quality of products. Automated lines were developed and introduced into the production of KNIIM. The plant becomes the leading manufacturer of multiple launch rocket systems. In order to fulfill orders of considerable size, the work was organized mainly in three shifts. Unfortunately, in the future, the automated lines for assembling products 9M22U and 9M53F in buildings No. 1 and 4, which had been idle since 1990 due to a lack of orders, were dismantled.

In July-August 1965, in accordance with the order of the Ministry of Defense Industry # 205 of July 9, 1965, TsKB-14 tested the Grad-D system, which included the standard M-21OF projectile and the 9P131 launcher. Joint tests of 9P131 were carried out with a standard M-21OF projectile. As a result of these tests, the following characteristics were obtained: the largest firing range - 20.4 km, accuracy: in the direction - Wb / X = 1/278, in range - Wd / X = 1/326.

The Grad-D system was recommended for adoption by the joint test commission, military unit 64176 and the MOP.

The M-21 field reactive system became the base for other domestic systems created in the interests of various types of troops:

- M-21V - field rocket system for airborne troops;
- A-215 "Grad-M" - shipborne MLRS for arming landing ships of the Navy;
- 9K55 "Grad-1" - multiple launch rocket system for ground forces;
- DP-62 "Damba" - coastal self-propelled jet bombing system;
- 9K59 "Prima" - multipurpose multiple launch rocket system for ground forces;
- 9K510 "Illumination" - a portable rocket system;
- 9F689 "Beaver" - target complex.

Its components also became the basis for the development work on the systems Grad-A , Grad-VD , Rosehip . For special delivery abroad, a light portable rocket system "Grad-P" was developed .

The M-21 system has become basic for foreign systems of a similar purpose:

- RM-70 , RM-70/85 , RM-70 / 85M - combat vehicles with an artillery unit from BM-21 for launching domestic and foreign rockets of 122mm caliber (Czechoslovakia, Czech Republic)
- APR - combat vehicle (Romania)
- APRA - series of combat vehicles for launching rockets of caliber 122mm (Romania)
- PRL111 and PRL113 - lightweight portable installations for firing rockets caliber 122mm (Egypt)
- Type 81 , Type 84 , Type 89 , Type 90 , Type 90A , Type 90B - combat vehicles for firing rockets of 122mm caliber (China)
- BM-11 - series of 30 and 40-barreled combat vehicles for firing 122mm rockets (North Korea)
- HADID - 30-barreled and 40-barreled versions of combat vehicles for firing 122mm rockets (Iran)
- BelGrad (Republic of Belarus)
- LAROM (Romania-Israel), Lynx (Israel), Naiza (Kazakhstan) - multiple launch rocket systems for ground forces (Israel, Kazakhstan)
- Modular - combat vehicle for firing rockets of 122mm and 227mm caliber (Slovakia - Germany)
- WR-40 Langusta combat vehicle for firing rockets of 122mm caliber (Poland)
- BM variants on the KRAZ chassis photo 1 , photo 2 , photo 3 (Ukraine)
- Homemade BM variants in Libya, Lebanon and possibly other countries
- Fighting vehicle MCL (Turkey-United Arab Emirates)
- Modernized (experimental) combat vehicle 2B26-KZ (photo 1 , photo 2) (Kazakhstan)
- Modernized (experimental) combat vehicle BM21-NA (Bulgaria)
- Fighting vehicle (Pridnestrovian Moldavian Republic)
- Experienced combat vehicle (Pridnestrovian Moldavian Republic)

For the first time, the M-21 system was used in hostilities during the border conflict on Damansky Island in 1969. Later it was used in hostilities in Angola, Afghanistan, Africa, Somalia, Georgia, the Chechen Republic, South Ossetia, Libya, Syria, Ukraine and other countries.

According to the recollection of Alexander Sergeevich Goryachev, a participant in the hostilities in the Democratic Republic of Afghanistan in the 80s of the twentieth century, about half of the ammunition was put into the transport vehicle to carry out combat missions, i.e. in fact, about 1.5 ammunition was transported.

In Russia, an algorithm has been developed for the modernization of standard Grad and Grad-1 MLRS missiles to increase the firing range up to 40 km.

Combat vehicles of various modifications were and are in service with the armies of the following countries: Azerbaijan, Algeria, Angola, Armenia, Afghanistan, Bangladesh, Bulgaria, Bosnia and Herzegovina, Burundi, Hungary, Venezuela, Vietnam, Germany (Group of Soviet Forces in Germany), Greece, Georgia, Egypt, Zambia, Israel (trophies), India, Iran, Iraq, Yemen, Kazakhstan, Cambodia, Cameroon, Cyprus, Democratic Republic of the Congo, Kuwait, Kyrgyzstan, Liberia, Lebanon, Libya, Macedonia, Mali, Morocco, Mozambique, Moldova , Mongolia, Nigeria, Nicaragua, Pakistan, Peru, Poland, the Republic of Belarus (Belarus, the Red Banner Belarusian Military District), the Republic of the Congo, Russia (in the USSR, including the marines and the Northern Fleet, it is possible that the " Dam", Red Banner Siberian Military District, Order of Lenin Leningrad Military District, Central Group of Forces, Order of Lenin Moscow Military District, Red Banner Central Asian Military District, Northern Group of Forces, Red Banner Precarpathian Military District), Romania, Seychelles, Syria, Somalia, Union of Myanmar, Sudan, Tajikistan, Tanzania, Turkmenistan, Uganda, Uzbekistan, Ukraine (Red Banner Kiev Military District, Red Banner Precarpathian Military District), Finland, Croatia, Chad, Sri Lanka, Eritrea, Ethiopia, South Ossetia, South Africa
According to a report from FSUE ROSOBORONEXPORT , 51 Grad systems were delivered to the USA from Romania, which were probably purchased for research purposes (use as targets).

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Composition:

The composition of the field reactive system M-21:

- combat vehicle BM-21 (see diagram , photo) (later 2B17, 2B17-1 - prototype),
- unguided rocket M-21OF caliber 122mm (later other types of projectiles were included in the system),
- commercial vehicles for the delivery of ammunition both in a park cork (boxes) and in a set of 9F37 racks . In 2001, development work was completed to create a special transport vehicle 9T254 (see description).

The battery of the MLRS "Grad" has a control machine 1V110 "Birch" on a modified chassis of a GAZ-66 truck, with the help of which data preparation for firing is provided.

Compared to the combat vehicles of the previous generation, the BM-21 has the following design solutions introduced for the first time:

- cradle for mounting the rail package, i.e. there was a final refusal to use the truss as part of the artillery part for attaching the guides;
- cylindrical tubular guide with a helical guide groove;
- electric drive for guiding the turntable in elevation and azimuth;
- pneumatic equipment, which served as a drive for locking mechanisms of the swinging and rotating parts of the artillery unit and for turning off the vehicle chassis springs.

A number of structural elements and attachments of the BM-21 artillery unit became unified and were subsequently used for BM 9P125 MLRS "Grad-V" and BM 9P140 MLRS "Uragan".

BM-21 is a self-propelled rocket launcher, consisting of an artillery unit (see diagram) and a modified chassis of a Ural-375D truck with a gasoline engine. The artillery unit includes forty tubular guides, cradle, base, swivel, lifting and balancing mechanisms, shoulder straps, locking mechanism, frame assembly, sighting devices, pneumatic equipment, electric drives, auxiliary equipment.

The guides (see diagram) are 3 m long, the inner diameter of the smooth bore is 122.4 mm. To give the projectile a rotational motion during its movement along the barrel bore, a U-shaped screw groove is made in the guide, along which the projectile's driving pin slides. The guides are arranged in four rows of ten pipes each, forming a package. The package, together with the sighting devices, is fixed on a rigid welded cradle. Guidance mechanisms allow you to direct the package of guides in the vertical plane in the range of angles from 0 ° to + 55 °. The horizontal angle of fire is 172 ° (102 ° to the left of the vehicle and 70 ° to the right). The main method of guidance is from the electric drive.

The fire control system allows you to fire both single shots and a salvo. At the same time, the operation of the impulse sensor, which ensures the triggering of the pyro-igniters of the engines of the rockets, can be controlled both with the help of a current distributor installed in the BM-21 cockpit, and with a remote control at a distance of up to 50 meters. The duration of a full salvo is 20 seconds. Shooting can be carried out in a wide temperature range from -40 ° C to + 50 ° C.

The chassis of the combat vehicle is the chassis of the Ural-375D off-road truck (wheel arrangement bhb). This chassis has a V-shaped eight-cylinder ZIL-375 carburetor engine, which develops at 3200 rpm, a maximum power of 180 hp. from. The clutch is two-disc, dry. The gearbox is five-speed, with synchronizers in 2nd, 3rd, 4th and 5th gears. Due to the presence of a centralized tire pressure control system on the chassis, the launcher has a high cross-country ability on soils with low bearing capacity. When driving on the highway, it develops a maximum speed of 75 km / h. The depth of the ford overcome without preliminary preparation is 1.5 m. The cabin of the BM-21 combat vehicle is equipped with fire extinguishing equipment and an R-108M radio station.

The calculation includes the commander and numbers: No. 1 - gunner; No. 2 - fuse installer; No. 3 - loader (radiotelephone operator); No. 4 - transport vehicle driver - loader; No. 5 - combat vehicle driver - loader.

The guides are reloaded manually. For the delivery of shells in park closures (boxes), commercial vehicles are used.

The original loading rate for truck bodies with park closure was as follows:

car model	Number of boxes in the back, pcs.
GAZ-51	eighteen
GAZ-63	eighteen
ZIL-130	21
ZIL-131	21
ZIL-151	24
ZIL-157	24

To deliver shells without boxes, ZIL-157 trucks were used, in the back of which a set of 9F37 racks, right and left, was installed. Such a vehicle is called a transport vehicle.

The BM-21 combat vehicle was put into mass production in 1965.

For the M-21 system, a 122-mm unguided missile M-21OF was developed (see diagram , photo), the design of which had a revolutionary effect on the development of rocket artillery systems of the indicated caliber. The body of the missile part of the projectile is made not by traditional cutting from a steel blank, but by a high-performance method of rolling and drawing from a steel billet (mug). This method is used in the production of artillery ammunition casings.

During the serial production of the M-21OF projectile, advanced technologies were widely introduced to improve the technical level of production, reduce the labor intensity and cost of the projectile, reduce rejects, and improve quality. In particular, as of 01.01.1967, over the three-year period of development of the M-21OF, the labor intensity of manufacturing was reduced from 205.5 n / h to 63.3 n / h.

After the adoption of the M-21 system, a number of R&D and research projects were carried out to create shells for various purposes, and special launchers. Shells MC-21 and MC-21M were created in special filling of warheads. The missile part of these shells was completely unified with the M-21OF shell. The MC-21 and MC-21M shells were adopted by the Soviet Army (*probably, these are shells with chemical warheads, known after being put into service under the indexes 9M23 and 9M23M*).

Description of characteristics	Shell MC-21	Shell MC-21M
Warhead weight, kg	18,7	19
Projectile weight, kg	66.7	67
Firing range, km	19	20

Accuracy of combat when firing at maximum range: -Vb / X -Vd / X	 1/118 1/172	 1/131 1/206
Scattering ellipse, ha	8	9

For the development of chemical projectiles, tactical and technical requirements (TTT) of GRAU No. 0010091 were issued (for 1 and 6 departments of the 1st Directorate of STC GRAU) (Supplement to TTT GRAU No. 0010044-60) for the development work "Rocket chemical projectile in equipment "R-35" and substance "60" with a proximity fuse based on a projectile for the "Grad" system (Code of work - "Leica"). *Note that the substance " 60 " was also envisaged to be used according to the TTT project on ROC in the warhead of the rocket " Temp-S "(1961), project TTT GRAU on ROC" Military missile system " Luna-M " (1961), in addition to TTT GRAU No. 0010086 "Development of the chemical warhead of the product" Luna-M "in a cassette version "and possibly other projects.*

In 1968, a special rocket 9M23 "Leica" (theme KRZ-122-61) (theme TULGOSNIITOCHMASH) was adopted and mastered in serial production with the Soviet army. At the meeting of the plenum of the NTS TULGOSNIITOCHMASH (Tula) in 1968, in particular, the issue of nominating candidates for the State Prize for the work " *Development of chemical ammunition for rearmament of the Soviet army (9M23,9M23M shells)* " was considered.

In 1971, the BM-21 combat vehicle was replenished with an MZ-21 unguided missile (index 9M22S) with an incendiary warhead. In the design of the projectile, the principle of cluster ejection of incendiary elements was first applied, which made it possible to increase the effectiveness of the ammunition by 30%.

In 1972, TulgosNIITOCHMASH performed work on the subject NV2-154-72 "Single-channel system of angular stabilization for Grad and Uragan projectiles (work started - 1st quarter 1972, finished - 2nd quarter 1973).

The search for the design of a single-channel angular stabilization system was carried out in two directions:

- based on an angular velocity sensor using gas-dynamic executive bodies;
- on the basis of a contact angle sensor with powder pulse actuators.

According to the report of TulgosNIItochmash in 1972, theoretical calculations, simulation on analog electronic machines, experimental laboratory studies of a single-channel angular stabilization system and its elements for unguided rockets of the Grad and Uragan type were carried out. It was determined that the use of this system improves the accuracy of fire by 1.5-2 times. At the time of compilation or submission of the report, a batch of system blocks was being produced for flight tests.

In 1972, on the basis of the order of the Chief of the 2 Main Directorate of the Ministry of Mechanical Engineering No. 17 dated December 20, 1970, TulgosNIItochmash carried out research work on the topic "Investigation of ways to create long-range projectiles for systems such as" Grad "and" Uragan "(topic HB2-110 -71g) The work performed has demonstrated the possibility of increasing the firing range of the Grad and Uragan projectiles through the use of durable materials for the hull and high-impulse fuels. the maximum firing range was 31-32 km.) However, a charge from this type of fuel did not provide performance in the temperature range of ± 50 ° C.

By 1975, the M-21OF shells with the indexes 9M22U, 9M22U-1, 9M22 were developed. Work on the MRV fuse for the M-21OF projectile was carried out by the Research Institute (Zheleznodorozhny) under the leadership of the head of the department, chief designer V.I. Pchelintsev. The design of the MRV provided for three installations: fragmentation action, small deceleration, large deceleration. Later, an MRV-U fuse was used. The MRV fuse (index 9E210) was used with M-21OF projectiles of 9M22U and 9M22 indices, the MRV-U fuse (9E244) with M-21OF projectiles of 9M22U, 9M22U-1, 9M22 indices.

The weights of the M-21OF projectiles of the 9M22U, 9M22U-1 and 9M22 indices, depending on the type of fuse and charge, are presented in the table:

Projectile designation	Projectile index	Fuse designation and index	Projectile weight
M-21OF	9M22U 9M22U-1	MRV-U (index 9E244)	66,60
	9M22U	MRV (index 9E210)	66.78
	9M22	MRV (index 9E210) MRV-U (index 9E244)	66.00 65.72

Initially, the warhead was equipped with an explosive to ensure the detonation of which a detonation bomb was installed. Later, work was carried out on the possibility of equipping it with a non-standard explosive, which made it possible not to install a detonation bomb.
The head part from the standard projectile of the Grad system was later used for the 9M22M and 9M22M1 projectiles of the Grad-P and Partizan systems.

The rocket engine of the M-21OF projectile is single-chamber, consisting of two tubes - one single-barrel charge of ballistic solid propellant 9X111 from RSI-12M powder in each chamber, but of different sizes - length, diameter and internal channels. The weight of the two charges is 20.45 kg. The charge was developed by NII-6 (chief designer B.P. Fomin), renamed in 1969 at TsNIIHM of the USSR Minmash, and now it is the State Scientific Center of the Russian Federation FSUE Central Research Institute of Chemistry and Mechanics (SSC RF FSUE TsNIIHM , Moscow city). Charge development years - 1959-1963. FTSDT “Soyuz” (Dzerzhinsky, Moscow region) together with TsNKB and LOMZ carried out work to improve the technology of mass

production, which made it possible to create and implement at the factories flow-mechanized lines for the production of the base charge 9XIII. This charge was used until 1968 with a shelf life of 40 years. For the M-21OF projectile of the 9M22U-1 index, charges of gunpowder RST-4K were used. The weight of the two charges is 20.5 kg. Work on the charge was completed in 1968, and it consisted of two identical pieces of ballistic solid propellant. This became possible due to the supply of longitudinal "ridges", which made it possible to abandon the "crackers". This was due to the density of the new fuel, which was 4-5 percent higher than the density of the RSI-12M fuel. The index of the new charge is 9XIIIM2. which made it possible to abandon "crackers". This was due to the density of the new fuel, which was 4-5 percent higher than the density of the RSI-12M fuel. The index of the new charge is 9XIIIM2. which made it possible to abandon "crackers". This was due to the density of the new fuel, which was 4-5 percent higher than the density of the RSI-12M fuel. The index of the new charge is 9XIIIM2.

The rocket engine of the M-21OF projectile of the 9M22U index was completely (100%) unified with the rocket engines of the 9M23, 9M23M and 9M22S (MZ-21) projectiles, and with the 9M22M projectile engine by 75%. There is also evidence that the missile part of the 9M22S projectile was completely borrowed from the M-21OF (9M22) high-explosive fragmentation projectile. The missile part of the M-21OF projectile of an unknown index was used for a set of 9M519 1-8 projectiles.

The above information indicates that when creating the projectile, a design approach known at least since the end of the 30s of the XX century was used - the use of a single missile part for various types of warheads, which was later used in the design of projectiles of the Uragan "and" Tornado ".

For the first time, the following design solutions were introduced into the design of a rocket artillery projectile:

- a two-tube single-chamber engine with single-barrel charges in each tube with different sizes of internal channels - a larger diameter in the head tube (head piece) and a smaller diameter in the tail tube (tail piece); The data previously published by the author on the two-chamber rocket engine for the M-21OF projectile are unreliable [29. C.16-17; 97].
- a nozzle block with a nozzle cover with seven nozzle holes (one central and six peripheral); The data previously published by the author on six and seven oblique nozzles in the design of the cover-nozzle for the M-21OF projectile are unreliable [94].
- folding blades of the stabilizer block, fixed after opening at an angle of 1 degree to the longitudinal axis of the projectile, which made it possible to create a package of guides with a larger number of guides than was required, which in turn increased the salvo power of one combat vehicle and ensured a decrease in the number of combat vehicles involved for performing the same type tasks in comparison with combat vehicles BM-24 and BM-14 type of the previous generation;
- cylindrical corrugated bushings with a diamond-shaped pattern for the warhead, which ensured the creation of a larger number of fragments during detonation of an explosive, and, consequently, their greater density and increased fragmentation effect on the target; The blanks (bushings) were connected at the ends by welding.

The initial rotation of the projectile is given due to the presence of a special spiral groove in the guide, into which the projectile's leading pin enters. The leading pin is located on the centering thickening of the tail tube of the rocket section, which serves to fix the projectile in the guide and prevent the projectile from turning in it. The stabilizer block became universal and was later used with some modifications for other shells of this caliber. For firing M-21OF projectiles at intermediate distances, small and large brake rings were used, which were installed between the fuse and the warhead.

The stabilizer block and the contact cover from the standard M-21OF missile were used in the design of the missile part of the 9M28F projectile.

The main types of ammunition of the M-21 system are:

- M-21OF (9M22U) with a high-explosive fragmentation warhead;
- MZ-21 (9M22S) with an incendiary warhead;
- 9M28F with high-explosive fragmentation warhead;
- 9M28S with an incendiary warhead
- 9M28D with a propaganda warhead
- 9M519-1 ... 7 a set of seven shells to create radio interference;
- 3M16 with a cluster warhead equipped with antipersonnel mines;
- 9M28K with a cluster warhead equipped with anti-tank mines;

In the 90s - early 2000s, in the interests of the foreign customer, the following long-range unguided rockets were developed, which have not yet been adopted by the Russian army.

- 9M521 with a high-explosive fragmentation warhead;
- 9M522 with a detachable high-explosive fragmentation warhead;
- 9M217 with a cluster warhead equipped with self-aiming warheads;
- 9M218 with a cluster warhead equipped with cumulative fragmentation warheads;

The use of the 9D51 (9D51.00.000) rocket unit with a bonded charge of high-impulse composite fuel in the 9M521, 9M522, 9M217 and 9M218 RS allows to significantly increase the total thrust impulse and reduce the overall dimensions of the rocket unit, thereby creating conditions for increasing the firing range and increasing dimensions and the masses of the head. The missile part 9D51.00.000 provides delivery of warheads for various purposes weighing 21-25 kg for a maximum range of 30 ... 40 km.

The upgraded 9M521 projectile, indexed AZ-DS-48, was adopted by the Russian Navy to equip the landing ships of the Navy.

In the interests of the Ministry of Defense of the Russian Federation, the following rockets were developed:

- 9M538 with high-explosive fragmentation warhead;

- 9M539 with a detachable high-explosive fragmentation warhead;
- 9M541 with a cluster warhead equipped with cumulative fragmentation warheads.

It is also possible to shoot chemical projectiles, 9M43 smoke-smoking projectiles (ten projectiles of this type create a continuous curtain of smoke over an area of 50 hectares), 9M28D propaganda projectiles, as well as 9M42 lighting projectiles, illuminating a circle with a diameter of 1000 m on the ground from a height of 450-500 m for 90 seconds.

Also, a projectile with a fire mixture was worked out and, possibly, was created. See Tactical and technical requirements No. 0010282 (addition to TTT military unit 64176-C No. 0010044 -60) on the ROC "Warhead equipped with a fire mixture for the Grad rocket (electronic version)

In other countries, various versions of projectiles based on the M-21OF projectile and other types of 122 mm projectiles were created. The following countries are known that have carried out and / or are carrying out work on shells of caliber 122 mm: Romania, Egypt , China , Italy , France together with Poland, South Africa , Turkey , Serbia , Sudan , Bulgaria , Slovakia , Yugoslavia (now a defunct state), Iran , North Korea, Israel , Indonesia (1 , 2). In the United Arab Emirates, the assembly work of TPK was organized forRS caliber 122 mm .

Modernization

In 1986, the ROC “Creation of the BM-21-1 combat vehicle of the 122-mm MLRS 9K51“ Grad ”was completed. The customer of the work was GRAU of the USSR Ministry of Defense. The lead contractor is Motovilikhinskie Zavody (Perm). A modified chassis of the Ural-4320 truck began to be used as the base of the combat vehicle (see photo 1 , photo 2 , diagram). Unlike the BM-21 guide tube package, a heat shield was installed on the BM-21-1 guide tube package to protect the pipes from direct exposure to sunlight. However, there were options without a screen on a new type of chassis (photo). From the cockpit of the BM-21-1 (designation - 2B17) it is possible to fire without preparing a firing position, which makes it possible to quickly open fire. According to the relevant decree, from January 1, 1987, work began on equipping the guide packages with heat shields as part of artillery units mounted on the chassis of Ural-375 trucks. BM-21-1 is in service with the ground forces of Abkhazia, Azerbaijan, Armenia, Afghanistan, Georgia, Kazakhstan, Russia and possibly other countries.

In the late 90s, early 2000s, work was carried out to create an automated combat vehicle based on the BM-21-1. The designation of the new sample is 2B17-1 (see diagram). The main method of firing 2B17-1 is from the cockpit without topogeodetic preparation of the firing position with a slope of no more than 3 degrees, with guidance and firing without leaving the crew from the cockpit without using sighting devices. Possible guidance with exit from the cockpit using sighting devices and shooting from cover from a remote control.

Fighting vehicle 2B17-1 is equipped with an automated guidance and fire control system (ASUNO), which provides:

- information and technical interface with the control machine;
- automated high-speed reception (transmission) of information and its protection from unauthorized access, visual display of information on the computer screen and its storage;
- autonomous topographic location and orientation on the ground with displaying the location on the computer screen;
- automated guidance of a package of guides, without leaving the calculation from the cab;
- determination of the coordinates of the location using satellite navigation equipment.

An automated version, designated 2B17M (see photo1 , photo2), with the protection of the information transmission device was also worked out . One of the options for an automated combat vehicle is shown in photo 3 .

At the MVSV-2006 exhibition (Moscow) a mock-up of a projectile with an angular stabilization system for the Grad MLRS was demonstrated (see photo).

Recently, work was carried out on the 2B26 MLRS "Grad" combat vehicle on the modified chassis of the KamAZ-5350 truck.

Characteristics:

	BM-21	BM-21-1
Chassis	Ural-375D	Ural-4320-02; Ural-4320-10; Ural-4320-31
Dimensions, mm: - length in the stowed position - width in the stowed position - width in the firing position - height in the stowed position - height at the maximum elevation angle - height in the position of the swinging part 0 °	 7350 2400 3100 3090 4350 2680	 7370; 7370; 7740 2400 3100 3090 4350 2680
Distance from the center of gravity of the charged BM to the axis of the balance bogie of the car chassis at an elevation angle of the swinging part of 0 °, mm	-	1160

Weight, no more, kg: - BM without shells and calculation - BM of a charged combat vehicle with calculation	10870 13700 ± 1%	11120; 11120; 11950 14060; 14060; 15050
Maximum speed of movement of a charged BM on paved roads, km / h	75	75
Maximum ford depth, taking into account the wave, overcome by the BM, mm	1500	1500
Ammunition, pcs	120 NURS	120 NURS
Reduced area of destruction by BM volley, ha: - manpower - equipment	2.44 1.75	- -
Number of tubular guides, pcs	40	
Full salvo time, s	-	20

Guide length, mm	3000	
Inner diameter of the guide	122.4	
Rail weight	23.4	-
Elevation angle, degrees: - minimum - maximum	0 55	
Angle of horizontal fire, degrees: - to the right of the axis of the vehicle chassis - to the left of the axis of the vehicle chassis	70 102	
Cabin bypass angle, degrees	± 34	
The smallest elevation angle of the package in the cab area, degrees	eleven	
Electric guidance speed: - elevation - azimuth	not less than 5 ° / s not less than 7 ° / s	
Manual guidance speed (per turn of the flywheel): - in elevation - in azimuth	4 minutes 6 minutes	

Testing and operation:

In the article by the authors Medvedev V.I. and Autukha D.N. "Fruitful cooperation continues," data is given that in 1956-1957 work began on the creation of jet engines for MLRS "Grad", however, it is worth noting that it would be correct to write jet engines for a missile or shells in the future Field Jet systems M-21 (MLRS "Grad").

From 04/09/1963 to 04/16/1963, NII-100 tested a 122mm 9M22 rocket fired from a missile-receiver system from batch No. OP-121-63g manufactured at NII-147. The tests were carried out according to the program ref.0641ss from 02/05/1963 NII-147 with changes agreed with representatives of NII-147.

The purpose of the tests was to determine the dispersion of *"122 mm rockets 9M22 / 3OF10 / fired from the missile-receiver system, when fired at maximum range* ." For testing were delivered 122 mm 9M22 projectiles in the standard equipment of drawings Inventory 4492, 4849 batches No. OP-1-62, OP- (2) -63 and dummies of 122 mm 9M22 projectiles in inert equipment batch No. OP-10-62 NII- 147. The equipment of the missile parts and the assembly of the projectiles were carried out at NIIII-100 in accordance with the requirements of the drawing, inv. 4847, with RSI-12 / K powder charges with VGA-80-EZ igniters.

" *Barrel powder charges were prepared from gunpowder brand VG-NDSI of various weights. When testing the accuracy of the battle, they used fuses MRV / V-588 /, combat, with installations on "O" and "M", designs NITI-11. The tests were carried out with a guide, which is a semi-closed pipe that allows the use of a barrel charge and is installed on the carriage of the KS-12 anti-aircraft gun.*

Before firing for accuracy with 9M22 projectiles, mock-ups were fired on the missile-receiver system in order to select the weight of the barrel charge and determine the ballistic characteristics of the 9M22 projectile without and with a barrel charge.

Firing 9M22 projectiles for the accuracy of the battle with and without a barrel charge was carried out by shooting 2 groups / 7 projectiles in a group / at a maximum range with a guide elevation angle of 50 °. The temperature of the barrel and powder charges of the 9M22 shells was within + 20 ° ± 3 ° C " .

The conclusions of the NIIII-100 indicated that "the *9M22 shells of batch No. OP-121-63 of the NII-147 with a barrel charge when fired from the missile-*

barrel system showed better results in terms of range and combat efficiency than 9M22 shells without a barrel charge".

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Data from the reports on the work of the Tula State Research and Production Institute of Precision Engineering (now OAO NPO SPLAV, Tula).

1966 year

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Warhead equipped with a fire mixture for the Grad rocket, product 9M22S (topic HB6-001-66)

A warhead equipped with a fire mixture is intended to defeat enemy manpower outside of cover, in open trenches, communication trenches and trenches, as well as his military equipment. The defeat is carried out both by direct hit and by the creation of massive fires. Shooting should be carried out with the adopted combat vehicle for the "Grad" projectile.

In 1966, technical assignments for processing warhead elements were developed and issued to related organizations. Working drawings of two variants of the warhead have been developed. The first prototypes of warheads were made (50 pieces of each version) and sent for testing in the military unit. 33491. Bench and bench-flight tests were carried out in the amount of 42 pieces.
In 1967, it is necessary to submit a technical design of a warhead with a justification for the choice of a fire mixture and to make 500 shells for field tests.

"Warhead equipped with a fire mixture for a portable missile (9M22M), product 9M22MS"

The warhead, equipped with a fire mixture, is intended to defeat, in freezing temperatures and in dry seasons, enemy manpower outside the shelter, in open trenches, communication trenches and trenches, as well as his military equipment located in the firing range. The defeat is carried out both by direct hit and by the creation of fire centers.

In 1966, in accordance with the order of the Ministry of Defense Industry No. 490 dated 15.UII.66g, a technical assignment was developed and issued to related organizations for the development of elements of the warhead. Prototypes were made and bench, bench-flight and flight tests were carried out in the amount of 45 items with positive results. The warhead is equipped with an MSO fire mixture and an igniting-explosive charge based on yellow phosphorus, provides crushing, spreading and ignition of the fire mixture, in conditions of positive temperatures in the dry season, at speeds of meeting with an obstacle of about 400 m / s. Crushing the fire mixture into pieces weighing 3-5g meets the requirements for fire shells. Maximum firing range 9940m. Accuracy of fire at range VD / X = I / 200; in the direction Wb / X = 1/100.

Manufactured and delivered in v.ch. 33491 100 pieces of products, of which: for control tests - 30 products, for acceptance tests - 70 products.

In v.ch. 64176-C and 6 Main Directorate of the Ministry of Defense Industry sent a technical report, technical and operational documentation.

9M23 chemical projectiles loaded with R-33 with 9E310 and 9M23M radio fuses loaded with R-35 with 9E210 percussion fuse for the Grad system.

Work was carried out to eliminate the shortcomings in the 9M23, 9M23M projectiles and the 9E310 radio fuse in accordance with the list set out in the conclusion of the commission on field tests.

The technological process of the internal varnishing of the projectile has been worked out, the permissible defects of the weld and the welding mode have been established. Prototypes were made, defects in technical documentation were eliminated.

The radio fuse 9E310 has been improved in terms of ensuring its strength and tightness.

Sent to v.ch. 64176-C and 6 Main Directorate of the Ministry of Defense Industry, a report on the modifications carried out, a set of technical and operational documentation and posters of shells and a radio fuse.

Providing technical assistance to the Shtamp and Sibselmash factories in the manufacture of the Grad shell.

Throughout the year, the institute's specialists provided the factories with technical assistance in the serial production of shells at the Shtamp plant and in mastering the production of shells at the Sibselmash plant.

The work carried out jointly with the Shtamp plant to improve technological processes made it possible to significantly reduce the labor intensity and cost of manufacturing the projectile and ensure the fulfillment of the annual plan.

The Institute produced an experimental batch of hulls, which made it possible to significantly reduce the labor intensity and production cost of the projectile and ensure the fulfillment of the annual plan.

The Institute has manufactured a pilot batch of warhead hulls from a 16 mm thick blank instead of 22 mm. The technological process was issued to the plant, which manufactures the tooling for its introduction into production. The savings in metal will be 0.5 kg per item.

Together with the Shtamp plant, the standardization of cone frame blanks with heating by high-frequency currents was introduced instead of the furnace. An increase in the quality of heat treatment of workpieces and an increase in labor productivity have been achieved.

Technical documentation for casting on melted models of the grating and diaphragm of the intermediate and tail was developed and issued to the plant for implementation.

plant for implementation.

The technological process of coating the intermediate diaphragm by galvanizing followed by phosphotizing and impregnating with AB-4 varnish with a dye has been worked out.

Together with the plant, work was carried out to introduce, for operations 3 and 4 of the engine pipe extracts, the process of sludge-free etching and phosphotizing at the AMF-8 unit.

Organizational and technical measures for 1966-1967 were developed jointly with the plant. aimed at reducing rejects and improving quality. As a result of their implementation, losses from defects were reduced by 40% compared to 1965.

The labor intensity of the manufacture of the Grad projectile at the Shtamp plant was reduced in 1966 from 72 n / h to 64.3 n / h, the prime cost was 218.5 rubles (according to the data for the third quarter of 1966) with the planned - 296.06 rubles ...

The Institute, together with TNITI and the Shtamp plant, developed measures aimed at further reducing the labor intensity and cost of the Grad projectile by introducing mechanization and automation of main and auxiliary works, reducing metal consumption, and improving labor organization. The introduction of these measures makes it possible to reduce the labor intensity of manufacture in 1967 to 40 n / h and bring it in the future to 15 n / h.

A team of specialists from the institute rendered technical assistance to the Sibselmash plant in the development of production and the manufacture of an established batch. The plant has mastered and launched the production of rockets of the Grad system.

The developed measures to reduce the cost of products allow to obtain in 1967 a significant economic effect: (based on the volume of production in 1967): for 122-mm rocket "Grad" - 3990.0 tons.

On the topic “Creation of an automatic line for heat treatment of HFC (quenching and tempering) of semi-finished products of engine casings of a rocket projectile“ Grad ”(type TM6-409-65), working drawings of an automatic line were developed in 1966.

Parts hardening and tempering are automatically performed on the line. The functions of workers when working on the line are reduced to loading and unloading the line, to monitoring and monitoring its work.

The use of the line will reduce the labor intensity of 1000 workpieces at plant No. 176 from 181.6 h / h to 50 h / h, or 3.6 times. In 1967, it was planned to manufacture a prototype of the line.

1967 year

Warhead equipped with a fire mixture for the Grad rocket, product 9M22S (topic HB6-001-66)

A warhead equipped with a fire mixture is intended to defeat enemy manpower outside of cover, in open trenches, communication trenches and trenches, as well as his military equipment. The defeat is carried out both by direct hit and by the creation of massive fires. Shooting should be carried out with the adopted combat vehicle for the "Grad" projectile.

By a joint decision of the MOP and V.ch. 64176 dated March 25, 1967 (out. No. 6-1451 dated March 29, 1967), the warhead is being tested in equipment with electronic elements.

In 1967, working drawings of two variants of the warhead were developed. Manufactured and tested in v.ch. 33491 prototypes, 50 pieces each. The technical design for the warhead equipped with electronic elements has been approved (Decision of subsection No. 1 of section No. 1 of the NTS MOP ref.18 / 693ss of 12/25/1967; conclusion of the war unit 64176-D, ref. A / 1028779ss of 12/21/1967).

In 1968, it is necessary to revise the warhead to eliminate the shortcomings noted in the conclusion of V.ch. 64176-D according to the technical design. To produce 500 shells for field tests and issue recommendations for field tests.

In 1968, research will be carried out to develop directions for the development of multi-barreled missile systems.

Development of the design and manufacturing technology of the "Grad" missile warhead from a pipe billet (topic TT6-629-67)

In accordance with the approved methodological plan for carrying out work on this topic, drawings and manufacturing technology for the shell of the projectile and cold-rolled pipes have been developed.

According to the agreed technical conditions, the Chelyabinsk Pipe-Rolling Plant supplied a pilot batch of cold-rolled pipes, from which prototypes of billets were made.

A schedule has been developed and approved by the Ministry and GRAU, providing for the production of a batch of blanks at the Shtamp and Sibselmash factories with the completion of work in October 1968.

The introduction of a new technology for manufacturing warhead blanks makes it possible to reduce the duration of the production cycle (by 20 operations), increase the metal utilization rate from 0.6 to 0.84 and reduce the labor intensity of one piece by more than 1 n / h.

For the successful completion of the topic, it is necessary to accelerate the construction of walls at the Geodesy Institute for shooting tests.

Providing technical assistance to the Shtamp, Sibtekstilmash and Sibselmash factories in the manufacture of the Grad shell.

Throughout the year, the Institute's specialists provided technical assistance in the serial production of shells at the Shtamp, Sibtekstilmash and Sibselmash factories.

The Institute, together with TNITI and the Shtamp factories, developed a set of measures aimed at further reducing labor intensity, cost and increasing the technical level of the Grad projectile production by introducing mechanization and automation of main and auxiliary operations, reducing metal consumption, and improving labor organization.

During 1967, at the Shtamp plant, with the participation of our specialists from this complex, the following measures were implemented:

1. Unified technological process for the manufacture of pipe blanks. The introduction of this process allowed to reduce the number of changeovers and the range of stamping tools and to reduce rejects in operations.
2. Manufacturing process of tail, intermediate and grating diaphragms by investment casting method. The economic effect amounted to 5850 rubles. For the program.
3. The process of cutting out 4-shaped grooves in the fairing on a die instead of milling with an annual economic effect of 6,665 rubles.
4. Carbide tools on the latest hoods in the production of pipes and warheads. In order to provide assistance, the institute manufactured 34 carbide matrices for the Shtamp plant.

Laboratory and flight tests of an experimental batch of Grad projectiles with TP-15AS thermal protective coating instead of the existing V-58 were carried out with positive results. The technical documentation for the production of the pilot batch at the Shtamp plant was developed and issued.

In order to eliminate thread stripping on the nozzle cover, the technology has been worked out, and drawings of the improved design of the platform for the manufacture of plastic parts have been developed for the Shtamp plant.

As a result of the implementation of measures, the labor intensity of manufacturing the Grad projectile at the Shtamp plant was reduced in 1967 from 64.3 n / h. Up to 40 n / h., The cost price is 180 rubles.

At the Sibtekstilmash plant, a team of specialists from the institute and the plant organized the serial production of stamped pipe blanks and warheads of the Grad projectile.

Along with this, a set of organizational and technical measures has been developed and implemented, aimed at reducing labor intensity with a reduction in losses from rejects in the production of blanks.

The introduction of work on the complex allowed the Sibtekstilmash plant to fulfill the plan for the production of stamped blanks in 1967, to reduce the labor intensity from 16 n / h. up to 10.2 n / h. and reduce losses from rejects in the head tube from 23.3% to 7.1%, in the tail tube from 14.8% to 7.3% and in the warhead hull from 9.4% to 0.5%.

At the Sibselmash plant, specialists from the institute and the plant mastered the serial production of the Grad projectile.

In order to reduce labor intensity and increase the technical level of production by organizing production lines at the mechanical and assembly areas, improving technological processes, a set of organizational and technical measures has been developed and partially implemented.

The implementation of the measures allowed the Sibselmash plant to reduce the labor intensity of the Grad shell production in 1967 from 88 n / h. up to 41n / hour.

The Institute has developed and issued to factories a directive technological process for the manufacture of the "Grad" projectile with artillery with a labor input of 20.7 N / h.

The specialists of the institute, together with the Chelyabinsk Pipe-Rolling Plant, developed technological conditions, manufactured and supplied cold-rolled pipes for the fairing for implementation by the Shtamp and Sibselmash plants.

To prepare the production of the 9M23 projectile at the Sibselmash plant, the institute prepared and sent technical documentation for mechanical and pressing processing, coatings and welding in carbon dioxide, as well as drawings of a welding station with an installation for automatic welding in carbon dioxide.

In order to accelerate the preparation of production, the Sibselmash plant received a complex installation for welding products 9M23.

On the topic Creation of an automatic line for heat treatment of high frequency current (hardening and tempering of semi-finished products of engine casings of the “Grad” projectile (topic TM6-409-65) , a sample line model YAT1 was made for the “Shtamp” plant.

After debugging and testing, the line will be delivered to the plant for implementation in production.

The line provides for the operations of parts hardening and subsequent tempering.

The line is equipped with loading and unloading devices.

The use of the line made it possible to reduce the labor intensity of heat treatment of 1000 shell blanks from 181.6 h / h to 50 man / h, or 3.6 times.

1968 year

Creation of the design of the warhead of increased fragmentation action for rockets "Grad" (topic HB6-170-68)

In 1968, on the basis of theoretical studies, working drawings were developed, warheads were manufactured and tested:

- with rational crushing into optimal fragments due to the use of a given crushing - 12 pcs;
- with ready-made spherical fragments - 6 pcs .;
- improved distribution of spherical fragments in the sphere of expansion - 6 pcs;
- use of new explosives with improved characteristics - 5 pcs;
- with ready-made arrow-shaped fragments - 10 pcs.

The test results show that the experienced warheads exceed the M-21OF warheads in fragmentation by 1.3-1.5 times, and the warheads with arrow-shaped elements by 1.7 times.

The work was to be completed in the III quarter. 1969 year.

Warhead equipped with a fire mixture for the Grad rocket (product 9M22S, subject HB6-001-66)

By a joint decision of the MOP and V.ch. 64176 dated March 25, 1967 (out. No. 6-1451 dated 29 / III-67), an incendiary warhead equipped with electronic elements is being tested. The incendiary warhead is designed to create massive fires.

In 1968, the factory stage of development in the amount of 200 shots was completed with positive results and a recommendation for field testing. (out. V. ch. 64176-D No. a / 775727 from 29 / UII-68, out. TGNIITM No. 3430 o 30 / IU-68).

A polygon batch of 500 pieces was made and delivered. Field tests were completed with positive results and a recommendation for arming the Soviet Army with the establishment of the shortcomings noted by the commission for field tests (ref. Item 33491 No. 002814 dated 31 / X-68).

Elimination of deficiencies and verification of the proposals of the commission for conducting field tests is carried out according to the plans approved by the Ministry of Mechanical Engineering and military unit 64176-C and should be completed in the II quarter of 1969 (outgoing TGNIITM No. 7833 dated II / XI-68 and No. 81 from 8 / I-69).

The necessary technical documentation was sent to the factories for the preparation of serial production.

According to data from November 1997, the Indian ammunition industry included "nine enterprises of various profiles, which almost completely meet the needs of the national armed forces: 125- and 105-mm tank shells are produced, 130-, 106-, 105- and 75- mm artillery shells, 122-mm NUR for MLRS type BM-21, anti-aircraft shells, mines, aerial bombs, cartridges for small arms of all calibers, various types of powder and explosives, including solid fuel for rocket engines. "

In 2004, Valentin Vasilievich Andreyev, a researcher at the Poisk Research Institute, was awarded the S.I. Mosin for work on the topic: "Electronic programmable fuses and equipment for remote platoon of the modernized MLRS" Grad ", Research Institute" Poisk ".

According to the recollections of Evgeny Mikhailovich Martynov *(at the moment, the deceased worker of the Splav enterprise (now JSC NPO SPLAV named after A.N. Ganichev (Hero City Tula))* , Minister V.V.Bakhirev, having visited our enterprise, expressed about "Grad" as follows: "This design is so perfect and original that many economically developed countries, having received samples of the developed system, for 20 years could not develop anything like this!" "Deputy Minister V.I. Nikolaev once told Evgeny Mikhailovich Martynov : "" Whatever you say, and the "Grad" determined the fate of many people! ".

In 2012, Evgeny Viktorovich Alekhin, General Director of FKP "Aleksinsky Chemical Combine", was awarded the S.I. Mosin for work on the topic: "Creation of a new press-fibrous heat-shielding material based on glass fibers to ensure an increased resource and reliability of the MLRS" Grad "," Smerch ", etc.".

According to data from 2018, at the production facilities of the Joint Stock Company "Machine-Building Plant" Shtamp "named after B. L. Vannikov" (Tula), work is being carried out on the head parts for the MLRS "Grad".

According to the data of 2019, work was carried out in Russia to manufacture 9X111 charges for the rocket engine (or engines) of the MLRS "Grad" from ballistic rocket fuel RSI-12M based on linseed colloxylin. Ballistic rocket fuel RSI-12M based on linen cellulose is offered instead of the fuel of the same brand, made on the basis of cotton raw materials and is intended for use as charges for the engine or engines of the MLRS Grad MLRS. It should be noted that the strength characteristics of the RSI-12M fuel based on linseed collixilin are higher than those of the standard composition, which is probably due to a higher degree of plasticization of the energy-intensive filling. Regarding accelerated climatic tests of RSI-12M fuel, the results showed that at a calculated equivalent temperature of 295 ° K, the shelf life of products is 15 years.

An abridged version of the materials is published in the source:

S.V. Gurov From the history of the development of the M-21 field reactive system (MLRS "Grad") and its variants // Weapons in historical events, human destinies, museum and private collections: materials of the International scientific-practical conference dedicated to the 140th anniversary of the Tula Museum of Weapons, 23- October 24, 2013 / Federal State Budgetary Institution of Culture “Tula State Museum of Weapons”. - Tula, 2014 .-- S. 11-24.

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Analogues by appointment and basing:

Multiple launch rocket system 9K515 "Tornado-S"

Multiple launch rocket system 9K57 "Uragan"

Fighting vehicle for RS SAKR

Fighting vehicle BM-14-17 (index 8U36)

Multiple launch rocket system HIMARS

Fighting vehicle RM-70

System M-14

Multiple launch rocket system 9K512 "Uragan-1M"

Experienced multifunctional MML launcher

DP-62 Damba coastal self-propelled jet bombing system

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